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A CASE STUDY ON THE TRANSMISSION OF INFECTIOUS HEPATITIS BY RAW CLAMS - REPORT FROM GREENWICH, CONNECTICUT

Mila E. Rindge, et al

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A Case Study on the

TRANSMISSION OF INFECTIOUS HEPATITIS By RAW CLAMS

Report from Greenwich, Connecticut

Mila E. Rindge, M.D., M.P.H.
J. David Clem, B.S.C.E.
Robert E. Linkner, B.S., M.S.C.E.
Leslie K. Sherman, B.S., M.S.

Sanitary Engineering Services and Epidemiology Section
Connecticut State Department of Health
and Shellfish Sanitation Branch
Division of Environmental Engineering and Food Protection
U.S. Public Health Service

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FOREWORD

The relationship between contaminated waters and the safety of shellfish foods from these waters has been understood since the late 19th Century. By 1925, close and interlocking cooperative efforts had been achieved between shellfish-producing States, the industry, and the Public Health Service in order to protect public health and assure effective sanitary supervision of shellfish-producing areas.

In the cooperative program in effect, operating controls are exercised by the States in accordance with national standards established by the Public Health Service. Sanitary surveys are a most important aspect, and State health or conservation personnel continually inspect and survey bacteriological conditions in all State shellfish-growing areas to determine which areas are safe.

State supervision of contaminated areas is also very important because once shellfish have been taken from polluted waters, it is extremely difficult to tell contaminated oysters, clams, and mussels from safe ones. The only way to keep such shellfish off the market is to keep them from being harvested in the first place. Therefore, harvesting is restricted in polluted waters and these areas are patrolled and warning signs are posted.

What can happen when sanitation control measures are faulty was vividly demonstrated in 1961. During that year, cases of infectious hepatitis related to the consumption of raw shellfish from polluted waters were reported to the PHS Communicable Disease Center, Atlanta, Georgia. Special attention was given to this fact by the Connecticut State Department of Health and an attempt was made to obtain information regarding the consumption of raw shellfish by Connecticut people having infectious hepatitis.

The results produced by the investigation of this outbreak make clear the importance of an adequate program which will prevent the harvesting, marketing and consumption of shellfish from polluted waters, and emphasize the continuing need for research, technical assistance, and the training of shellfish sanitation personnel at Federal, State, and local levels.

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AUTHORS

Mila E. Rindge, M.D.	Chief, Epidemiology Section, Connecticut State Department of Health
J. David Clem	Sanitary Engineer, Shellfish Sanitation Branch; Division of Environmental Engineering and Food Protection, Public Health Service
Robert E. Linkner	Sanitary Engineer, Division of Environmental Engineering and Food Protection, Region II, Public Health Service
Leslie K. Sherman	Chief, Recreation, Shellfish and Eating Place Sanitation Sections, Connecticut State Department of Health

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INTRODUCTION

Fifteen persons having infectious hepatitis were found to have eaten raw clams taken from polluted waters in Greenwich Cove, Connecticut (Appendix A1, A2). In order to gain a better understanding of the relationship between levels of pollution and the transmission of the virus of the disease, the State department of health investigated the sanitary conditions, hydrographic features, and sources of pollution in the area.

The Connecticut investigation is just one of several studies currently being carried on by Federal, State, and local health departments throughout the country. Much information is still needed and as more outbreaks of this nature are reported, it may be possible to determine to what extent the level of coliforms or E. coli bacteria in sea water relates to the transmission of the infectious hepatitis virus. Until there is a specific laboratory test for the virus, its presence in domestic sewage will have to be inferred from association with high levels of the indicator organisms, e.g. coliforms or E. coli.

Description of the Area

The Town of Greenwich, Fairfield County, Connecticut, has a population of 53,793 (1960), an increase of 13,000 persons since 1950. There are 48 square miles of land area in the Township. Principal communities located along the coast in the Greenwich Township include Greenwich, Cos Cob, Mianus, Riverside, East Portchester and Old Greenwich. Greenwich is 28 miles northeast of New York City, on Long Island Sound (Appendix B).

The residents of the Town of Greenwich enjoy a high socio-economic status. The 1960 median yearly income per person 14 years of age and over in Greenwich was $4,261 while in Connecticut it was $3,548 and in the entire United States $2,798 (1).

The Town has three municipally owned beaches. Greenwich Point Park on Greenwich Cove, in Old Greenwich, has an area of 148½ acres which is restricted to the use of residents and their guests. The park is used for picnicking, day-camping, boating, swimming and informal sports.

The climate is mild with rainfall evenly distributed throughout the year. The annual mean temperature in Greenwich is 51.8°F. with a mean temperature May to September inclusive of 68.0°F. The mean annual rainfall is 46.48 inches while the mean monthly rainfall May to September inclusive is 4.10 inches (2). The nearest U.S. Department of Commerce weather station is located at Bridgeport, Connecticut, about 27 miles northeast of Greenwich Cove (Appendix C).

The Town has a Department of Health which is administered by a five-member Board of Health. The activities of the department--public health nursing, environmental sanitation, school dental program, and public health laboratory--are directed by the Director of Health who must be a physician trained in public health.

Epidemiologic Study

Viral hepatitis occurs as two types of infection, infectious hepatitis and serum hepatitis. They are not clinically distinguishable and no specific laboratory tests are available for diagnosis. Infectious hepatitis is spread by a fecal-oral route, usually from person to person, and occasionally by common sources. Its incubation period varies from 10 to 50 days with an average of 30 days (3). When spread from person to person, about sixty percent of those afflicted are twenty years of age or less. The disease has a familial pattern distribution. The common source outbreaks are characterized by a large proportion of cases occurring within several weeks and often a significant number of the persons are over twenty years of age. Rarely does infectious hepatitis spread by a blood route.

Serum hepatitis is spread only through blood or blood products from an infected person. The incubation period varies from 60 to 160 days with an average of 90 days. Characteristic of transmission is a sporadic distribution; however, it may have a common source pattern. Fatality among infectious hepatitis patients is about 2 percent while in serum hepatitis it varies from 6 to 12 percent.

Patients with either infectious or serum hepatitis have some or all of the following symptoms: fever; loss of appetite; nausea; vomiting; aches in the head, back or joints; tenderness of the liver; dark urine; clay-colored stools; loss of energy; and yellowing (jaundice) of the eyes or skin.

The relationship of infectious hepatitis to the consumption of raw shellfish has only recently been recognized. In 1955 an infectious hepatitis outbreak was reported in Sweden involving 119 patients who had consumed raw oysters contaminated by shoreline storage in polluted harbor waters (4, 5, 6). A 1961 outbreak of infectious hepatitis was investigated in Pascagoula, Mississippi, involving 85 cases attributed to the consumption of raw oysters harvested at the mouth of a polluted river (7, 8). Concurrent with the Pascagoula outbreak, 495 persons with infectious hepatitis in New Jersey were known to have eaten raw clams. Eighty percent of the patients had eaten clams coming from the Raritan Bay area (9).

The Greenwich Cove case histories of infectious hepatitis were reported by local directors of health to the Connecticut State Department of Health, using a routine questionnaire (Appendix D). Certain criteria had to be met before a case of infectious hepatitis was considered associated with the consumption of raw clams: 1) ingestion of raw clams 10 to 56 days prior to onset; 2) no known contact with an infected person within 6 months; 3) no known injection, inoculation, or dentistry within 6 months preceding illness;

and 4) no known history of blood transfusion within 6 months preceding illness.

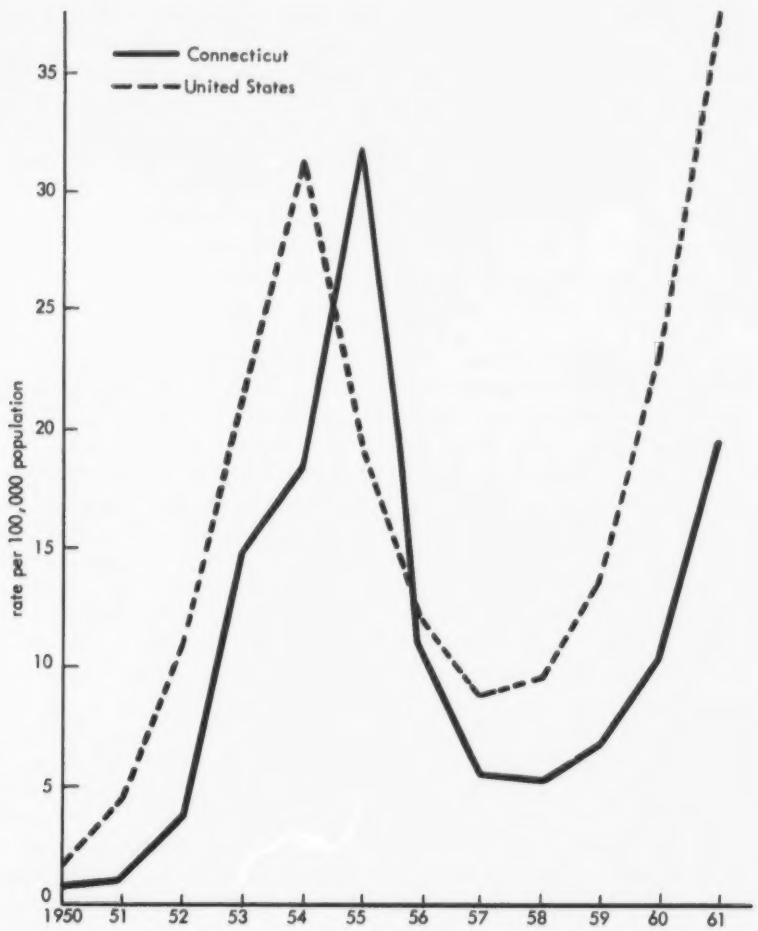
The 15 patients who reported having consumed raw clams dug in Greenwich Cove, Connecticut, all had onsets of the illness within 56 days after exposure except one patient with an incubation period of 64 days (Appendix E). The 15 patients also satisfied criteria 2, 3, and 4 except that three patients had injections within two months prior to onset. Other modes of transmission could have been responsible for these cases such as gatherings, water supply, milk, public eating establishments, vegetables and fruits, place of employment, injections, contact with infected persons, or blood being drawn; however, none of these possible modes were common to the 15 patients. The distribution of the 15 cases, 11 in the Town of Greenwich, two in Stamford, and one each in Darien and Norwalk, Connecticut, did not show any close association except that in one family both the husband and wife were ill (cases #14 and 15 in Appendix E). If the city water supply had been contaminated it would have resulted in many more cases and within a shorter time period. The only factor in the case histories of the 15 patients was the consumption of raw clams, Mercenaria mercenaria. (It is not thought that raw clams are a regular food item in the diet of Connecticut residents. Other investigators studying similar groups in New Jersey found that in control groups of healthy people, approximately 10 percent of adults and 4 percent of children gave a history of eating raw clams within 120 days.)

The 15 patients all reported eating clams dug from Greenwich Cove, Connecticut. This area was known to be polluted, and had been involved in a typhoid fever outbreak involving consumption of raw clams during August and September, 1945 (10). In light of this, the Town of Greenwich Board of Health had passed an ordinance requiring a permit from the Health Officer to dig clams in his jurisdiction (Appendix F-1). This permit allowed residents to take shellfish for bait only from the area described on the permit, including Greenwich Cove. The wisdom of this decision was even more evident when a similar area in another town was involved in the transmission of disease by shellfish. Clams which were illegally harvested 200 yards from the outfall of the Boulevard Sewage Treatment Plant in New Haven, Connecticut on October 10, 1948, were the direct cause of a fatal case of typhoid fever. The victim died 37 days after consuming 24 raw clams from the New Haven Harbor (11). After the infectious hepatitis-clam outbreak from Greenwich Cove was recognized, the Town of Greenwich issued a regulation to prevent all harvesting of clams from the areas of questionable sanitary quality (Appendix F-2).

Infectious hepatitis cases for Greenwich, Connecticut and State of Connecticut, 1952 to 1961

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Greenwich Township[1].....	2	8	13	11	1	7	6	3	7	32
State of Connecticut[2]....	76	319	405	724	249	124	122	161	258	483

[1] See reference 12
[2] See reference 13



Infectious Hepatitis[1] case rate per 100,000 population, United States and Connecticut, 1950-1961.

[1]Includes both serum and infectious hepatitis.

Sanitation of Shellfish

Commercial harvesting, processing and shipping of shellfish from Connecticut is endorsed by the Public Health Service under the provisions of a cooperative program participated in by the industry, 23 States, Canada, Japan, and the Public Health Service. Each participant agrees to follow the Manual of Recommended Practice for Sanitary Control of the Shellfish Industry developed by the U.S. Public Health Service (14, 15). Criteria for this Manual were initially developed in 1925 and have been frequently revised. No known disease outbreaks have occurred involving the consumption of fresh or frozen oysters, clams, or mussels when the technical criteria and administrative procedures have been maintained.

The 1961 infectious hepatitis outbreak from the Town of Greenwich did not involve any commercial harvesters. Surreptitious digging by sportfishermen and consumption of "bait clams" were responsible for the illnesses and the episode points out the need for constant enforcement of measures to protect the public from such occurrences, and for public education concerning the dangers involved. Greenwich Cove was well posted and warnings clearly stated that shellfish taken from those waters should not be eaten.

Contaminated shellfish can not be detected by visual inspection of the meat because pathogenic bacteria and viruses are microscopic and only a small number may cause diseases. Clams feed on particles in suspension--sand grains, dirt particles, spiny diatoms, bacteria, dinoflagellates, unicellular algae including non-spiny diatoms, protozoa and other microscopic animals as well as particles of industrial wastes, organic chemicals (pesticides), radioactive substances and toxins. The hard clam, Mercenaria mercenaria, feeds through a siphon containing two tubes. Water enters one of the tubes bringing oxygen and food to the mantle which collects rejected materials and concentrates them for expulsion. The larger particles are surrounded by a copious discharge of mucus and are rejected before reaching the mouth. Thinner mucus food strings enter the stomach readily but the separation of deleterious particles is not perfect and much useless material enters the clam's stomach while considerable amounts of food are rejected as pseudo-feces.

The digestive tract of a clam is well developed. Food passes through a mouth, stomach, and intestine and is expelled through the excurrent siphon as true feces. Other parts of the anatomy include gills for breathing and sorting food masses, heart, kidney, liver, reproductive system and muscular foot. The foot of the clam is used to burrow itself in the mud and sand. The entire animal, including its viscera, is usually consumed when eaten raw.

The habitat of the hard clam, Mercenaria mercenaria, is the intertidal zone waters along the east coast from the Gulf of St. Lawrence to Florida and the Gulf of Mexico (16). The clam reaches maturity in 2 to 4 years and attains a length of 3 to 5 inches. The desirable depth of water is from the lower third of tidal range to water 30 feet deep. Optimum salinity and temperature for growth and reproduction varies from 12 to 28 parts per thousand and 5° to 20°C respectively. During the winter months with a corresponding drop in water temperatures between 0° and 5°C the clam feeds less actively and in some cases lies dormant. The sedentary life of the clam makes it susceptible to its environs and therefore it must adapt to the changing ecology.

Sanitary Survey

To understand how the clams dug by the patients had become contaminated, their source was thoroughly investigated. There was no unusual handling, preparation or storage of the clams, and it was suspected that contamination occurred before the clams were harvested. Shellfish grown in even moderately polluted water can become grossly contaminated (17, 18, 19). The very nature of their feeding mechanisms concentrates food and other particles as they filter the water. Approved growing waters for shellfish must be clean and free of domestic and industrial pollution.

The U.S. Public Health Service manual specifies that shellfish growing waters meet the following criteria:

a. The area is not so contaminated with fecal material that consumption of the shellfish might be hazardous, and

b. The area is not so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous.

c. The coliform median MPN* of the water does not exceed 70 per 100 ml. and not more than 10 percent of the samples ordinarily exceed a MPN of 330 per 100 ml. (for the 3-tube decimal dilution test) in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.

A sanitary survey of Greenwich Cove was initiated to study the sources of pollution, the bacteriological quality of the water, the hydrographic characteristics of the cove and adjacent waters and other factors that affect the sanitary quality of shellfish. The State department of health in 1947 conducted a shore line survey of the area and located direct discharges from septic tanks and raw sewage. Many of these outlets had since been eliminated and according to a 1961 shore line survey, there were only two homes at Greenwich Cove not being serviced by the Greenwich sewerage system. These homes had a chlorination unit on their sewage discharge line but this type of installation had not proven reliable.

At the head of Greenwich Cove is a mile long tidal creek with practically no dry weather flow of fresh water (Appendix G) and effluent from the Old Greenwich Sewage Treatment Plant entered the creek approximately one mile above its mouth. The plant was built in 1926 and remodeled in 1932 for primary treatment of 800,000 gallons of sewage. Sewage treatment plant equipment included a bar rack (mechanically cleaned), followed by a comminutor,

*MPN - Most Probable Number

settling tank, heated digestor with floating cover, chlorine contact chamber, sludge storage tank, and open sludge beds.

The operation of the sewage treatment plant during the period when the patients harvested their clams from the last week in December 1960 to April 20, 1961, was similar to the time when water samples for bacteriological analysis were collected January 8 to February 6, 1962 (Appendixes H1, H2). The 1961 connected population was 9,700 with an average daily flow of 1,400,000 gallons. The average settleable solid removal for 1961 was 97 percent.

The effluent is not chlorinated in the winter months. In 1961, chlorination of the effluent began April 22 and continued through November 2 with an average dose of 119 pounds of liquid chlorine per day. Residuals ranged from 6.6 to 15.0 parts per million with an average of 11.9.

When the sewage flow rate is more than 1.8 million gallons per day (MGD), the excess is by-passed to an old septic tank that is able to handle an additional flow of 1.6 MGD. This, in effect, is another primary settling tank. The records indicate that many days have flows greater than 1.8 MGD but the maximum flow rate the meter will record is 2 MGD. Therefore an accurate measurement flow being by-passed to the septic tank could not be determined.

Above the outlet from the sewage treatment plant is a small stream from a lake. The lake is fed by two small forks that form the head water for the lake, stream and creek draining into Greenwich Cove. During flood tides it was noted that effluent backs into the lake and even heavy chlorination and other odor control measures were unable to prevent the obnoxious conditions on summer evenings. Industrial wastes, as well as domestic wastes, were apparently present in the creek. Goldfish, once quite plentiful in the lake, had been killed in the polluted waters. The only other pollution sources known to contribute to Greenwich Cove were pleasure craft. A marina in the Cove has been very active in the summer months, having as many as 50 to 200 boats at anchor.

The water quality of Greenwich Cove was studied by the State department of health and the Public Health Service January 8 to February 6, 1962. This period of time was considered the best for possible duplication of conditions, such as sources of pollution, temperatures, degree of sewage treatment, and hydrography as they existed when the patients dug their clams December 1960 to April 1961.

Water samples were collected from five preselected sampling stations (Appendix I). Samples were collected on January 8, 9, 15, 16, 29 and 30 and February 5 and 6, 1962. The time selected for collection was designed to study the four different tide phases (high tide, half ebb, low tide and half flood). On each day two samples

from each station were collected in an attempt to sample two of the tidal phases. The effluent from the Old Greenwich Sewage Treatment Plant was also sampled. Salinity measurements were made concurrently with sample collection using a laboratory set of hydrometers.

The water samples were collected at the surface in 0.6 liter, wide mouth, glass stoppered bottles. The bottles were put in an ice chest and transported to the Connecticut State Health Department water laboratory in Hartford. The water was tested the day after arrival so that elapsed time from Cove to the testing laboratory did not exceed 24 hours.

The water samples were tested for the coliform organisms and then further differentiated using the E.C.$^+$ (Fecal Coliform) partially confirmed (E.C.$^+$ gas positive) test according to APHA Standard Methods (20) and APHA recommended procedures for the examination of sea water and shellfish respectively (21). Water bath incubation at $44.5 + 0.2^{o}C$ was used for the E.C.$^+$ gas positive test. The most probable number of coliforms and E.C.$^+$ organisms per 100 ml. of water sampled were derived from set of three tubes employing three dilutions (Appendix J-1).

Preliminary review of the bacteriological data during the study indicated no correlation between tidal phase and bacteriological quality. Highest coliform results were noticed at stations at low tide on one day, and then again on another sampling day the highest result occurred at high tide. However, what was significant was the coliform strength of the effluent from the Old Greenwich Sewage Treatment Plant. Associated with the high coliform counts of the effluent were corresponding high coliform counts at the various stations, thus overriding tidal considerations. Sampling was then continued with emphasis directed to the quality of the treatment plant effluent being discharged. Review of the bacteriological data in Appendix J-3 reveals that the sewage treatment plant effluent coliform MPN was consistently high and was the major pollution source influencing the water quality of Greenwich Cove (Appendix J-2).

The MPN results from the coliform and E.C.$^+$ gas positive tests were plotted on logarithmic probability paper as described by C. J. Velz (22). If all the water samples collected had come from a discrete pollution source with little variation, the plotted MPNs should approximate a straight line. In every case a straight line did develop and no abnormal variation by virtue of the test procedure was apparent (Appendix K.)

E.C.$^+$ gas positive results are reported since the test procedure is thought to enumerate a good indicator of fecal pollution (19, 23). However, no standard has been established for shellfish growing waters using this test procedure.

In April, 1961, Dr. Erval Coffey, Director of Health of the Town of Greenwich, packed some clams from Greenwich Cove in dry ice. The clams were shipped to the Public Health Service Communicable Disease Center, Atlanta, Georgia, for bacteriological examination. These samples were examined for salmonella and shigella organisms with negative results. (A portion of the sample was put in storage at -72°C for future use when effective methods for culturing the hepatitis virus in the laboratory evolve.)

Hydrographic Study

Greenwich Cove is a confined estuary three-quarters of a nautical mile wide by one and one-quarter nautical miles long and has an average depth at mean low water of 4 feet (Appendix L). It opens to Long Island Sound through a passage 0.2 miles across and 18 feet deep at mean low water. Little fresh water enters the Cove and most flushing is caused by tidal influence. Maximum current velocity recorded in January 1962 at the passage was 0.6 knots at 230° true north during ebb tide (Appendices M-1, M-2). The greatest ebb and flood currents occur approximately midway between the high and low tide stages. The maximum winter range of tide heights from the nearest tide gage located at New Rochelle, New York and extrapolated to Greenwich Cove by observed tidal relations was 10.0 feet (24). The normal mean range of tide at Greenwich, Connecticut is 7.4 feet, the spring tidal range is 8.7 feet and the mean tide level is 3.7 feet (25). The tide is typically semidiurnal.

The salinity and temperature of Greenwich Cove for January and February 1962 ranged from 15 to 30 parts per thousand and 0° to 4°C. No stratification was noticeable in any part of the Cove. At low tide the entire estuary up to one-quarter mile in the creek from station number 5 was saline. Fresh water was not detectable at low tide until one-quarter mile up the creek from sampling station number 5. During high tide the creek was saline up to a point one-quarter mile above station number 5. Appendices N-1 and N-2 show the relative salinities throughout the Cove at high tide and low tide.

Surface floats, namely oranges, dropped near the outfall of the Old Greenwich Sewage Treatment Plant during the ebbing tide, required one and one-half hours to reach station 5. During flooding tide, surface floats required two and one-half hours to reach station 5. Thus, the effluent from the sewage treatment plant under the best conditions could reach the clam beds in about two hours.

No appreciable stratification in current velocities was observed during the float studies, and the fact that no noticeable salinity stratification exists supports the conclusion that a homogeneous cross-section for salinity and current is a characteristic of this shallow body of water. The flushing of the Cove is accomplished strictly by the tidal prism or by wind action. Active flushing occurs in the northwestern section of the Cove between station 5 at the mouth of the creek and station 2 at the passage entering Long Island Sound. From the hydrographic studies it is estimated that two tidal cycles are required before a slug of sewage entering the creek at the outfall will reach Long Island Sound, providing its course of travel were in the channel from station number 5 to station number 2. The southeastern section of the Cove experiences very low

velocities and is extremely dead in the pocket at Greenwich Point Park as shown in Appendices 0-1 and 0-2. This is also evident from the salinity plot in Appendix P. The high salinity in this pocket shows that there is inadequate flushing. Clams are plentiful in most parts of the Cove and are found in quantities along the entire eastern shore and at the mouth of the creek. Flow at the mouth of the creek disperses in all directions and that which flows toward the eastern shore tends to follow the shoreline on its way toward Long Island Sound.

The floats used in the Cove were constructed of wood and aluminum. They were so designed that a 2 inch by 2 inch wood staff floated perpendicular to the water surface and submerged with only the top exposed (Appendix Q). At one end of the staff was attached four sheets of aluminum in the form of a cross. By varying the length of the staff and weight and size of the aluminum vanes, the direction and velocity of the current could be measured up to 4 feet in depth. For depths greater than four feet, a cord was attached to a surface float and a vane to the other. In this way, currents were measured up to 20 feet in depth.

The speed of the current was measured by noting the distance the surface float traveled from a fixed point in a unit time. A cord marked in 10.13 foot intervals (101.3 feet / min. = 1 knot) was tied to a float and for one minute the number of marks reeled out was the current velocity in nautical miles per hour (knots). Eight hydrographic stations were established in Greenwich Cove from which ten current measurements were made from each station at different tidal stages. During each measurement, the station location, depth of vane, water temperature, wind direction and velocity, current direction and velocity, specific gravity of the water and time of sampling were recorded.

CONCLUSIONS

Fifteen patients having infectious hepatitis reported consuming raw clams which were harvested from the heavily polluted waters of Greenwich Cove, Connecticut, between December 1960 and April 1961.

A sanitary survey and bacteriological study was conducted January 8 to February 6, 1962. Conditions existing at that time were considered to be similar to the water quality as it existed when the patients harvested their clams since the pollution sources, water temperature and hydrography of Greenwich Cove were similar for both the harvest and study periods.

Analysis of the data indicated that at no one particular time during a tidal cycle was pollution pronounced. The amount of indicator organisms in the Cove was directly dependent on the operation of the sewage treatment plant. The median coliform level varied from greater than 2,400 coliform MPN per 100 ml. at the mouth of the creek to 930 coliform MPN per 100 ml. at the passage. These coliform counts are greater than the recommended median 70 coliform MPN per 100 ml. for shellfish growing waters and indicate that domestic sewage had grossly polluted the Cove.

The source of the infectious hepatitis virus that infected the clams is suspected to have been present in the partially treated sewage treatment plant effluent from the 9,700 tributary population. The virus, after passing through the sewerage system, could have infected the Greenwich Cove clams in less than two hours causing the clams to be a potential health hazard for those who consumed them.

The Town of Greenwich completed a study and design program in 1960 to virtually eliminate the pollution in Greenwich Cove and adjacent waters. Construction began early in 1962 to build an 8.5 MGD activated sludge plant expected to treat the Town's 1980 sewered population. The Old Greenwich Sewage Treatment Plant site was used to build a pumping station. All sewage from Old Greenwich, Cos Cob, Byram, Riverside and Greenwich is to be treated at the one activated sludge plant located on Grass Island in Greenwich Harbor. The net effect of the new construction will be to reduce pollution in all harbors and coves in the Town of Greenwich since only Greenwich Harbor will receive treated sewage effluent.

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(25) U.S. Department of Commerce, Coast and Geodetic Survey: Tide Tables, East Coast, North and South America 1961. U.S. Government Printing Office, Washington, D.C.

(26) Rindge, Mila E.: Infectious Hepatitis in Connecticut. Conn. Health Bull. 76: (5)125-130, May, 1962.

(27) U.S. Department of Commerce, Weather Bureau: Local Climatological Data with Comparative Data. Bridgeport, Conn., 1961.

Appendix A-1. Origin of shellfish eaten by persons having hepatitis, Connecticut, 1961[1]

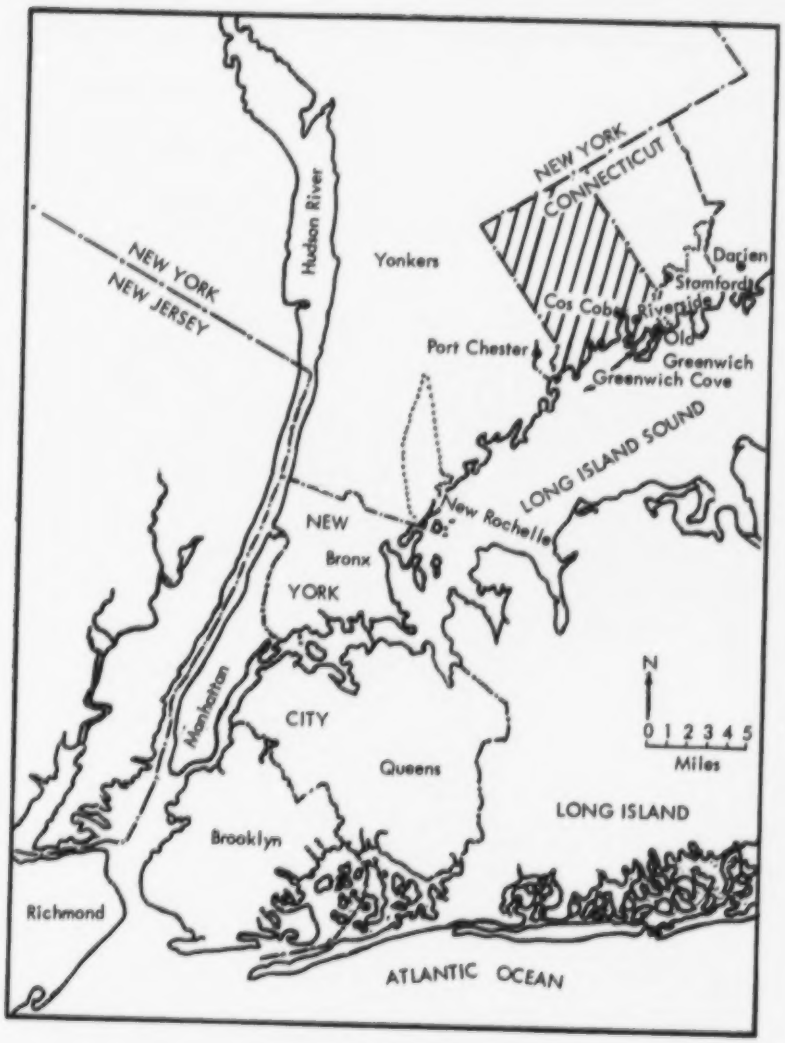
Mussels	
Eaten out of state	1
Eaten in Connecticut but originating out of state	1
Oysters	
Eaten out of state	8
Eaten in Connecticut but originating out of state	2
Eaten in Connecticut, source not determined	1
Clams	
Eaten out of state	15
Eaten in Connecticut but originating out of state	17
Eaten in Connecticut, source not determined	3
Eaten in Connecticut, originating in Connecticut	17
Dug in Greenwich	15
Dug in Norwalk	1
Dug in Stamford	1

[1] See reference 26

Appendix A-2. Hepatitis cases with history of recent consumption of raw shellfish, Connecticut, 1961[1]

	Less than 20 years of age	Age 20 and over	Total
Total cases of known-age	197	265	462
Number questioned for consumption of raw shellfish	102	191	293
Number giving history of consumption of raw shellfish	6	50	56
Percent of those questioned giving history of consumption of raw shellfish	5.9	26.2	19.1

[1] See reference 26



Appendix B. Greenwich Cove, Connecticut and vicinity.

Appendix C. Average monthly weather, Bridgeport, Connecticut[1]

Month	Temperature (°F.)			Precipitation (in.)
	Minimum	Average	Maximum	
January	21.8	29.2	36.6	3.43
February	21.2	29.0	36.7	2.97
March	28.8	36.9	45.0	3.60
April	37.4	46.3	55.2	3.49
May	47.7	57.2	66.6	3.60
June	57.9	66.9	75.9	3.47
July	63.9	72.8	81.6	3.97
August	62.9	71.7	80.4	4.43
September	56.1	65.2	74.2	3.55
October	44.7	54.4	64.0	2.83
November	35.2	43.5	51.8	3.59
December	25.0	32.3	39.6	3.08
			Total	42.01

[1] Reference No. 27.

INFECTIOUS HEPATITIS CASE RECORD Case # _____

Patient's name _____ Address _____

Occupation _____ Where employed _____

Age ____ Sex ____ Race _____ Date of onset of illness _____

Symptoms of illness: Fever ____ Anorexia ____ Nausea ____ Malaise ____ Jaundice _____

Abdominal pain _____ Dark urine _____ Clay-colored stools _____ Other _____

Hospital _____ Date admitted _____

Attending physician _____ Address _____

Census of household at time of patient's onset of symptoms: (include guests and servants)

Name	Age	Sex	Similar illness	Date given gamma globulin

Similar illness among friends or neighbors: _____

Previous hospitalization within 6 months: Yes _____ No _____

Where _____ Date admitted _____ Date discharged _____

Transfusions received: Blood _____ Plasma _____ Date _____ None _____

History of inoculations, injections or dentistry within 6 months preceding illness: _____

_____

History of blood being drawn within preceding 6 months: _____

_____

Consumption of raw clams or oysters within 8 weeks preceding illness: Yes _____ No _____

Date eaten _____ Type of shellfish _____

Where eaten _____ Source of shellfish _____

Milk supply _____ Water supply _____ Sewage disposal _____

Date reported _____ Director of Health _____ Address _____

Date investigated _____ By _____ Address _____

4/24/61

Appendix D. Infectious hepatitis case history report form, Connecticut State Department of Health

Appendix E. Case histories of infectious hepatitis patients Greenwich Township, Conn., January 1 to May 22, 1961

Case No.	Sex	Age	Occupation	Interval[1] (days)	Onset	Contact
1	F	13	Student	56	?	Ate raw clams within 2 months before illness
2	F	29	Housewife	56	2/16/61	Ate raw clams within 2 months of onset
3	F	37	Secretary	16	4/3/61	Ate raw clams 3/18/61
4	M	26	Unemployed	56	4/10/61	Ate raw clams 2 months before onset[2]
5	M	31	Gardener	56	4/13/61	Ate raw clams within 2 months
6	F	5	Child	19	4/20/61	Ate steamed clams 4/1/61
7	F	30	Housewife	20	4/24/61	Ate raw clams 4/3 or 4/4/61
8	M	15	Student	45	4/29/61	Ate raw clams 3/15/61
9	F	33	Housewife	28	5/2/61	Ate raw clams 4/4/61
10	M	32	Airline Pilot	64	5/4/61	Ate steamed clams 3/1/61
11	M	34	R.R. Engineer	30	5/8/61	Ate raw clams in early March and steamed clams 4/17/61
12	F	21	X-Ray Tech.	24	5/14/61	Ate raw clams 4/20/61[3]
13	M	51	Fireman	47	5/17/61	Ate steamed clams end of March and 1st April
14	M	35	Sales Manager	42	5/20/61	Ate raw clams and clam chowder 4/8/61[4]
15	F	40	Housewife	44	5/22/61	Ate raw clams and clam chowder 4/8/61

[1] Interval between ingestion of raw clams and onset of symptoms
[2] Tetanus injection two weeks before onset
[3] Polio shot 5/13/61 and flu injection several months earlier at Stamford Hospital
[4] Vitamin B_{12} injection early in May

Resident's Permit To Take Shellfish
FOR BAIT ONLY
Town of Greenwich, Connecticut

Date Issued

Greenwich Dept. of Health

Permission is hereby granted, subject to the orders of the Health Officer of the Town of Greenwich, and subject to revocation for failure to comply with Section 4 of the Sanitary Code of the Town of Greenwich.

to _____

residing at _____

_____

in the Town of Greenwich, to take shellfish *for bait only* from tidewaters and tidal flats within the jurisdiction of the Town of Greenwich; namely the area northerly of a line running from the New York-Connecticut state line at Byram

(over)

Front

Point to the end of Field Point and thence easterly to Flat Neck Point and that area northerly of a line running from Greenwich Point easterly toward Stamford Light as far as the Greenwich-Stamford boundry line and thence northerly along said line to the mainland.

SANITARY CODE OF THE TOWN OF GREENWICH
(Rev. Mar. 1, 1954)

Section 4. Shellfish. No person shall take shellfish from tide waters or tidal flats within the jurisdiction of the Town of Greenwich without a permit from the Health Officer; nor shall any shellfish so taken be sold without a permit from the Health Officer.

_____
Signed:

Back

Appendix F-1. Shellfish bait permit issued by Town of Greenwich, Connecticut.

REGULATION OF THE BOARD OF HEALTH

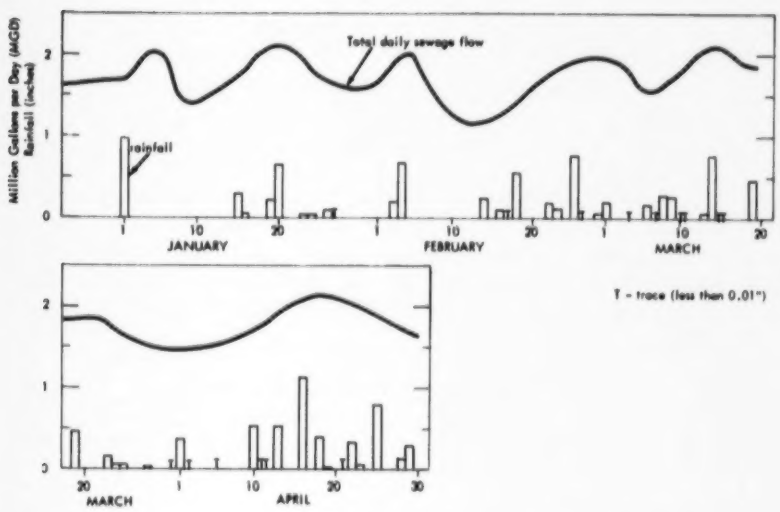
Greenwich, Connecticut

"Pursuant to the powers vested in the Board of Health by the General Statutes of the State of Connecticut and the Special Acts for the Town of Greenwich in order to promote, protect and preserve the health of the inhabitants of the Town of Greenwich, the following Subsection 1.8 is added to the Sanitary Code, SECTION 1. GENERAL, effective June 23, 1961:

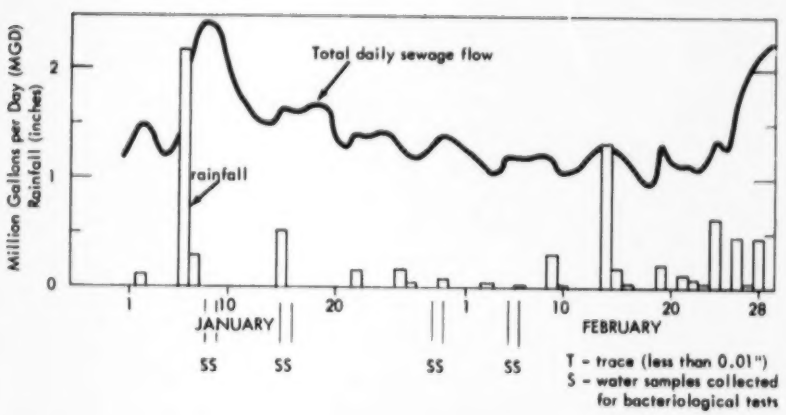
1.8 The taking of shellfish, other than by commercial harvesters authorized by the State of Connecticut, from the shoreline, tidal flats or waters located within the limits of the Town of Greenwich is prohibited."

Appendix F-2

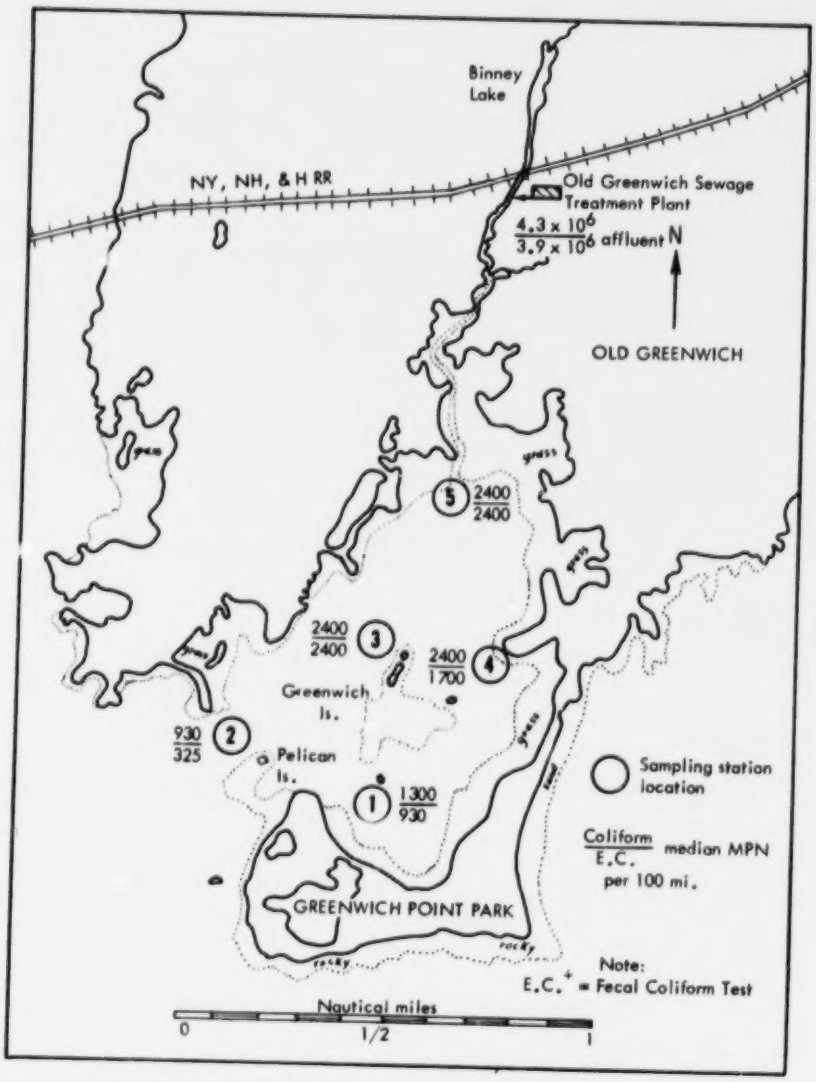
Appendix G. Creek (low tide) to which sewage treatment plant effluent was discharged.



Appendix H-1. Sewage flow for Old Greenwich Sewage Treatment Plant and precipitation recorded at Bridgeport, Connecticut, December 25, 1960 to April 30, 1961.



Appendix H-2. Sewage flow for Old Greenwich Sewage Treatment Plant and precipitation recorded at Bridgeport, Conn., January 1 to February 28, 1962.



Appendix I. Bacteriological results, Greenwich Cove, Conn., January 8 to February 6, 1962.

Appendix J-1. Coliform and E. C. + MPN per 100 ml. for Water samples collected January 8 through February 6, 1962

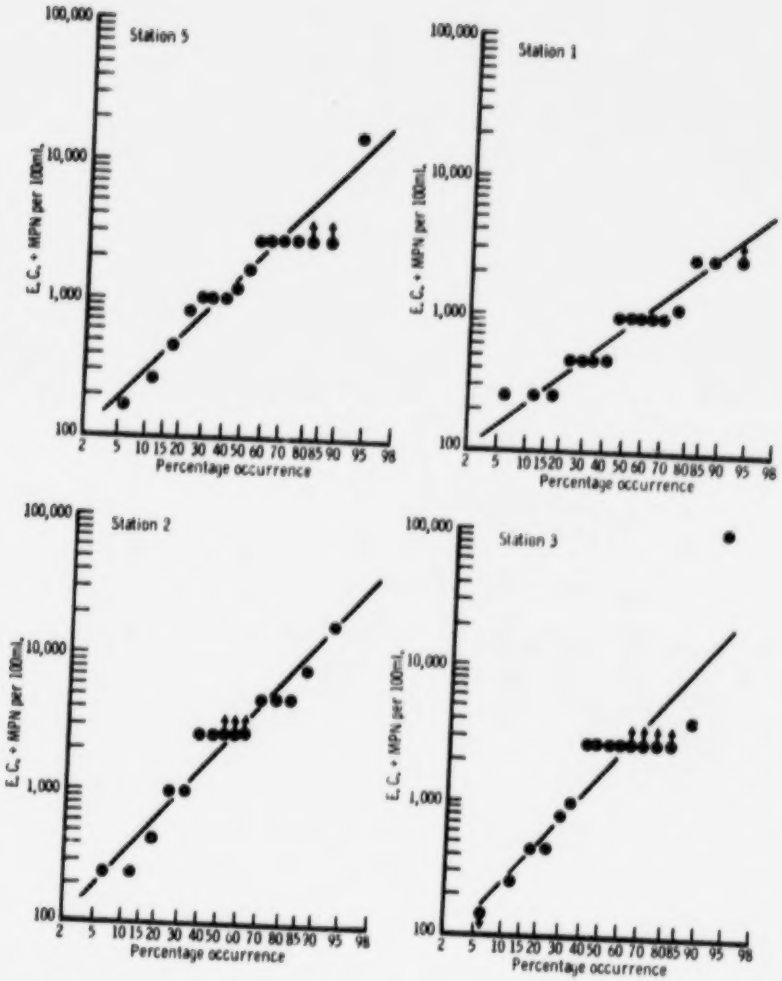
Coliform MPN/100 ml			Station number	Number of samples	E.C. + M.P.N./100 ml		
Probability percentile					Probability percentile		
10	50	90			10	50	90
260	1,300	6,800	1	16	64	580	5,000
210	740	2,600	2	16	40	310	2,400
310	1,900	12,000	3	15	80	1,000	14,000
210	1,500	11,000	4	16	37	850	20,000
270	2,800	28,000	5	16	64	1,600	37,000

Appendix J-2. Coliform MPN per 100 ml. of the Old Greenwich Sewage Treatment Plant effluent, January 8 to February 6, 1962

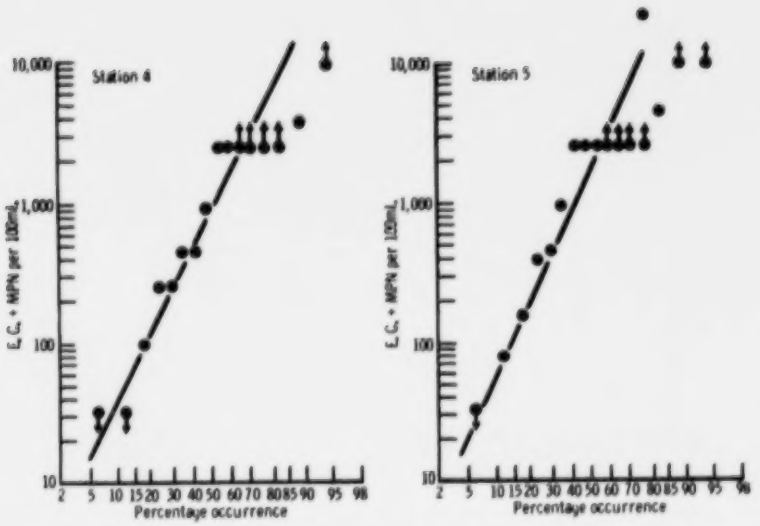
Date	Time of collection	Coliform MPN per 100 ml.
8 Jan. 62.....	10:10	3,900,000
9 Jan. 62.....	--	24,000,000
15 Jan. 62.....	10:00	29,000,000
15 Jan. 62.....	14:35	7,500,000
16 Jan. 62.....	11:50	46,000,000
16 Jan. 62.....	14:45	3,900,000
29 Jan. 62.....	12:05	15,000,000
29 Jan. 62.....	15:25	4,300,000
30 Jan. 62.....	11:45	3,900,000
30 Jan. 62.....	14:45	2,100,000
5 Feb. 62.....	11:00	<300,000
5 Feb. 62.....	13:45	4,300,000
6 Feb. 62.....	11:00	300,000
6 Feb. 62.....	14:30	46,000,000

Appendix J-3. Bacteriological Data for Greenwich Cove, Connecticut, expressed in MPN

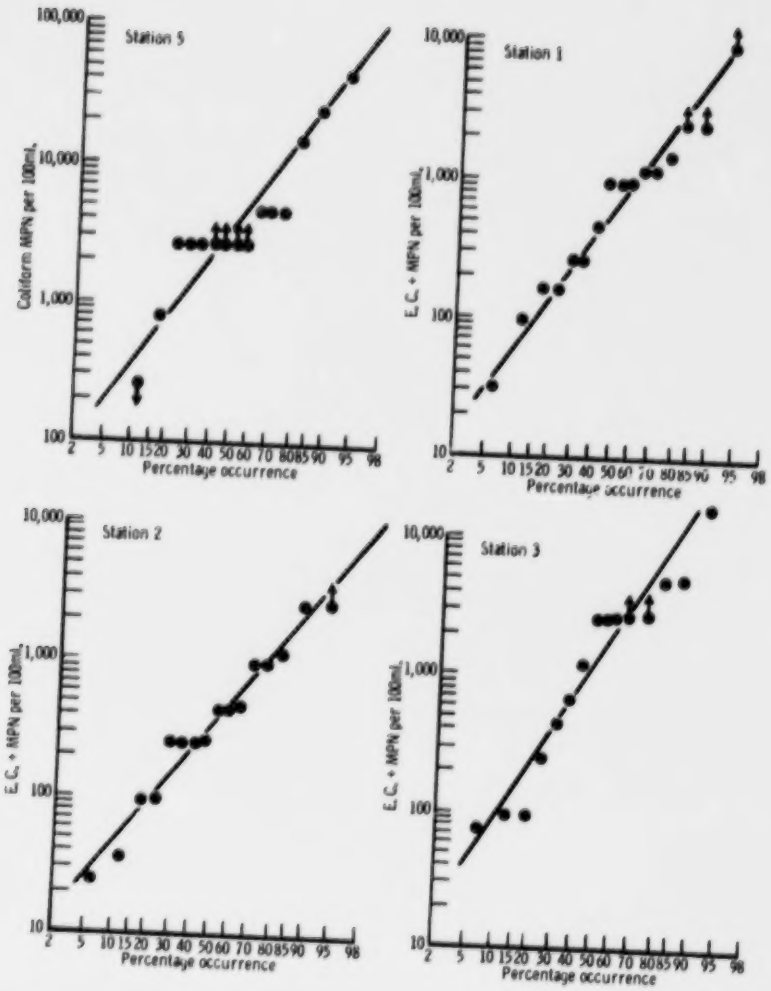
Date	Tide	Time of collection	Sampling station										Time	Sewage treatment plant effluent	
			1		2		3		4		5				
			Coliform	E.C.+	Coliform	E.C.+	Coliform	E.C.+	Coliform	E.C.+	Coliform	E.C.+		Coliform	E.C.+
1/8/62	Flood	8:50-9:10	>2,400	>2,400	>2,400	>2,400	Bottle	Broken	>2,400	>2,400	>2,400	>2,400	10:10	3.9×10^6	3.9×10^6
	high	12:05-12:25	>2,400	>2,400	1,100	1,100	>2,400	>2,400	>2,400	>2,400	>2,400	>2,400			
1/9/62	Flood	10:05-10:40	1,100	1,100	460	460	>2,400	>2,400	>2,400	>2,400	>2,400	>2,400			
	high	13:05-13:45	>2,400	1,100	460	240	>2,400	1,100	>2,400	>2,400	>2,400	>2,400		24×10^6	24×10^6
1/15/62	Ebb	10:05-10:35	930	930	930	430	230	91	2,400	2,400	2,400	2,400	10:00	29×10^6	29×10^6
	low	13:40-14:05	2,400	230	930	930	430	91	930	230	24,000	4,600	14:35	7.5×10^6	4.3×10^6
1/16/62	Ebb	10:40-11:20	2,400	930	930	930	2,400	2,400	3,900	3,900	46,000	46,000	11:50	46×10^6	2.8×10^6
	low	13:30-14:45	15,000	15,000	2,400	2,400	15,000	15,000	110,000	21,000	2,400	2,400	14:45	3.9×10^6	2.3×10^6
1/29/62	Low	11:25-11:55	2,400	930	930	230	7,500	640	2,400	2,400	4,600	73	12:05	15×10^6	4.3×10^6
	flood	14:25-15:25	230	230	230	91	930	73	2,400	930	230	150	15:25	4.3×10^6	$.73 \times 10^6$
1/30/62	Low	12:15-12:45	750	150	230	230	4,600	4,600	430	91	4,600	11,000	11:45	3.9×10^6	3.9×10^6
	flood	14:45-15:20	150	91	230	91	230	230	230	230	15,000	930	14:45	2.1×10^6	$.91 \times 10^6$
2/5/62	High	11:40-12:50	1,500	1,500	430	430	4,600	4,600	36	<30	<30	<30	11:00	$<.3 \times 10^6$	$<.3 \times 10^6$
	ebb	14:00-14:35	930	<30	2,400	36	930	430	750	<30	4,600	430	13:45	4.3×10^6	$.36 \times 10^6$
2/6/62	High	11:50-12:30	930	150	930	230	2,400	2,400	430	430	2,400	2,400	11:00	$.3 \times 10^6$	$<.3 \times 10^6$
	ebb	14:50-15:25	430	430	430	23	4,600	2,400	2,400	430	750	390	14:30	46×10^6	24×10^6



Appendix K. Logarithmic-probability plots of coliform and E.C.+MPN per 100 ml. from water samples collected from Greenwich Cove, Connecticut January 8 to February 6, 1961.

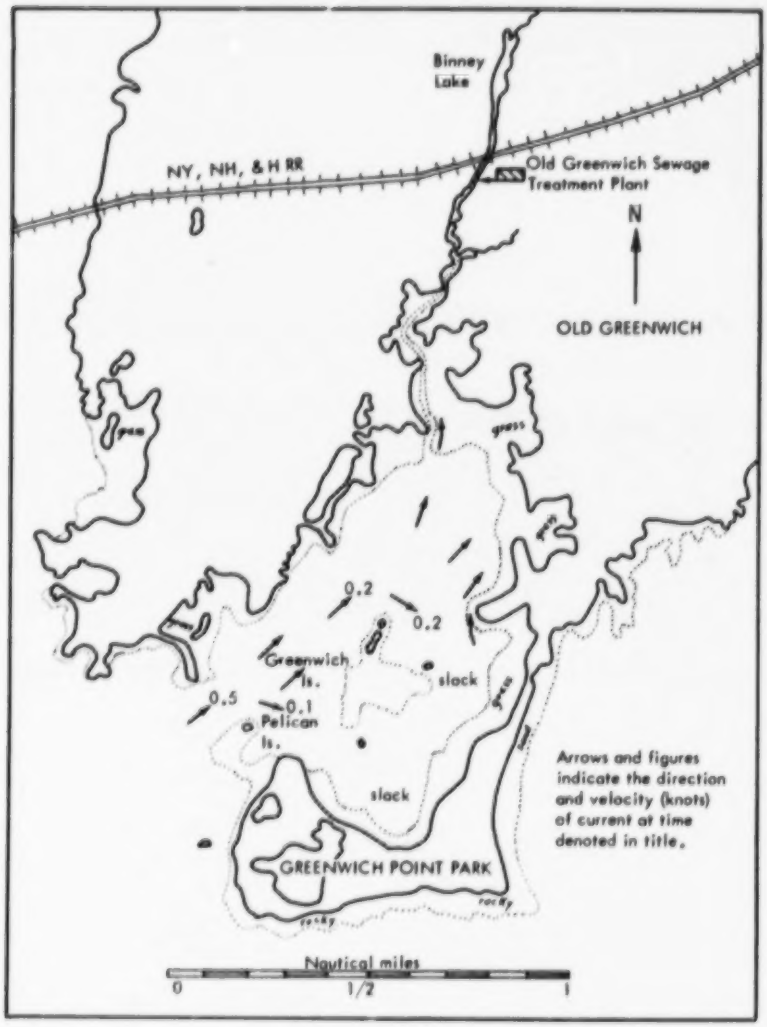


Appendix K. Logarithmic-probability plots of coliform and E.C. + MPN per 100 ml, from water samples collected from Greenwich Cove, Connecticut January 8 to February 6, 1961.

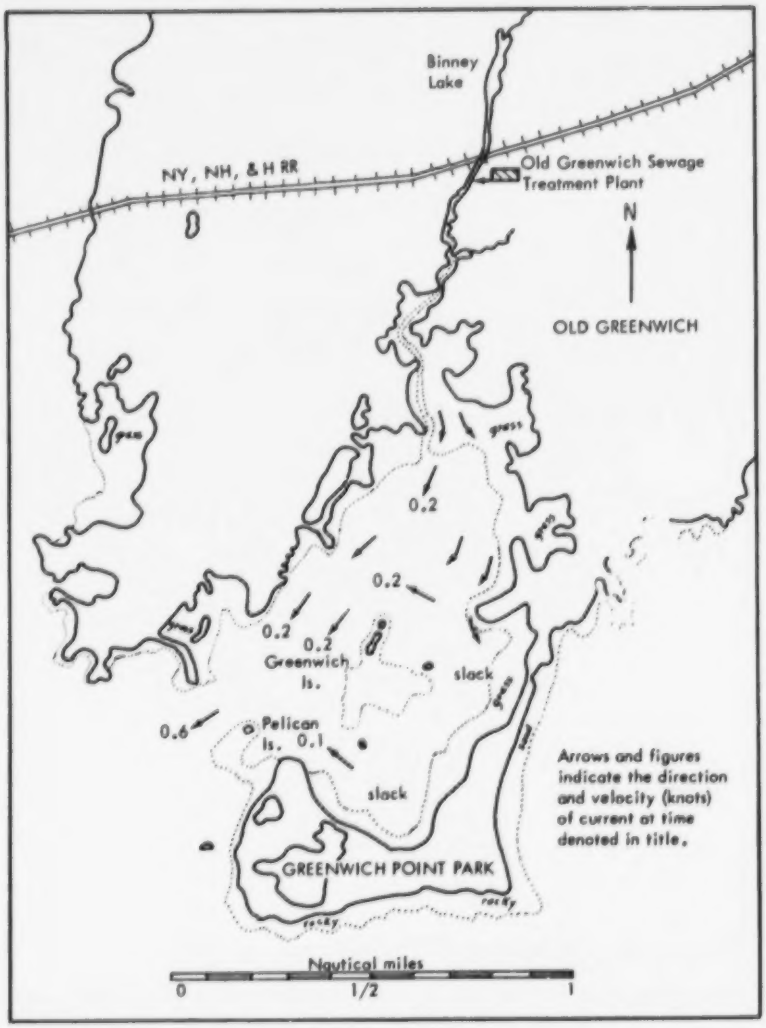


Appendix K. Logarithmic-probability plots of coliform and E.C.+ MPN per 100 ml. from water samples collected from Greenwich Cove, Connecticut January 8 to February 6, 1961.

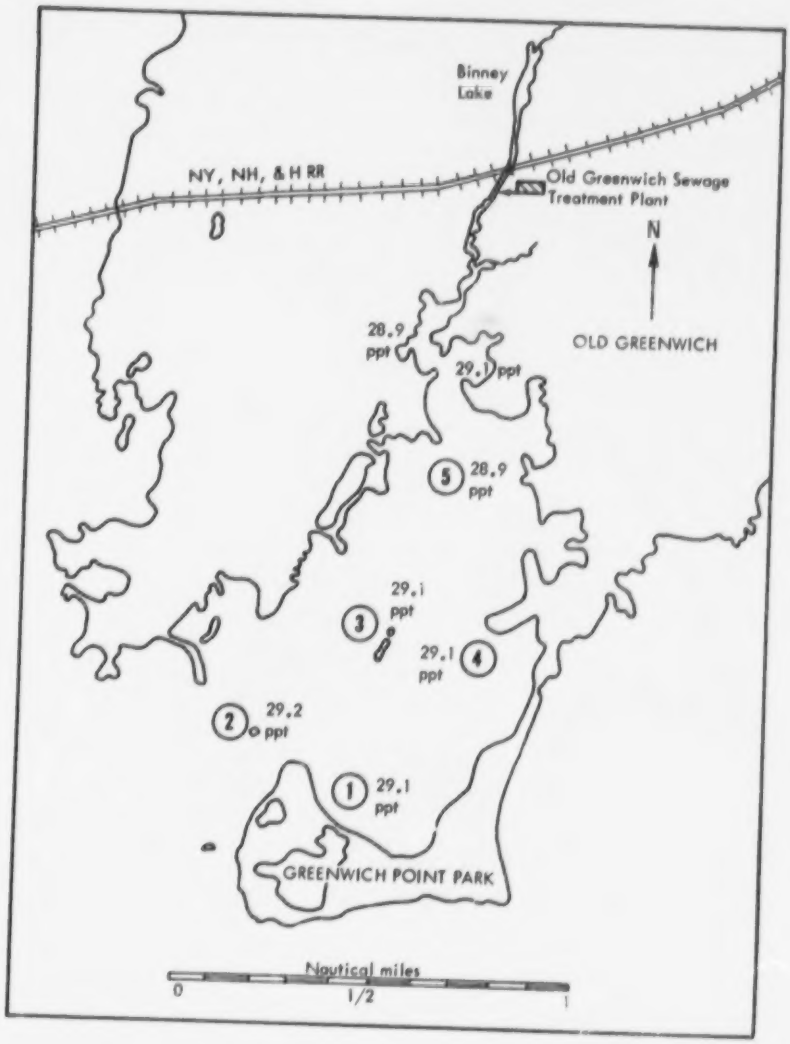
Appendix L. Greenwich Cove, Connecticut, typical of topography and shoreline.



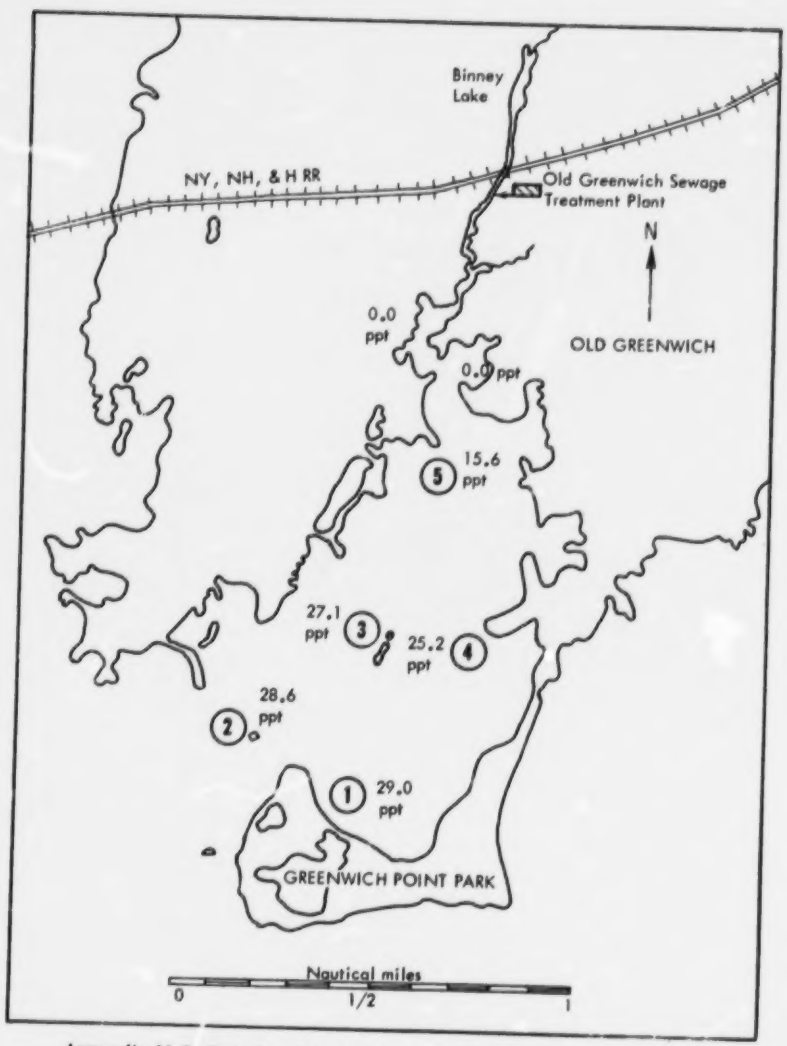
Appendix M-1, Current three hours before high water, Greenwich Cove, Connecticut.



Appendix M-2. Current three hours after high water, Greenwich, Cove, Connecticut.

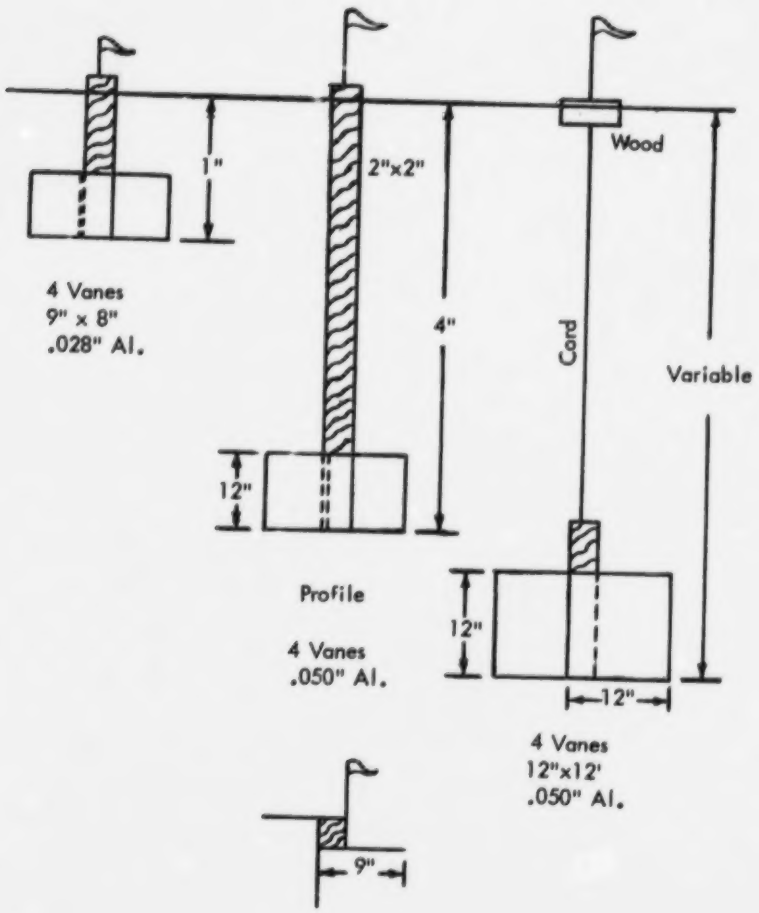


Appendix N-1, Relative Salinities in Greenwich Cove at High Tide



Appendix N-2. Relative Salinities in Greenwich Cove at Low Tide

Appendix O. Fleets employed in the Greenwich Cove study.



Appendix O. Fleets employed in the Greenwich Cove study.

GPO 882-804